January 4, 2008

Mr. David Walbeck
Water Management Administration
Nontidal Wetlands and Waterways Division
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, Maryland 21230

SUBJ: MDE Tracking No. 20076408 // 07-NT-3268
Capital Project No. S-6175: Little Patuxent Parallel Sewer Interceptor (LPPSI)
Howard County Department of Public Works, Utility Design Division

RE: Phase I (Conceptual) Mitigation Report

Dear Mr. Walbeck,

Howard County Department of Public Works (HODPW) Utility Design Division proposes to construct a parallel sewer interceptor generally following the course of the Little Patuxent River within Howard County, Maryland. Specifically, the project area consists of a corridor along the existing alignment of the Little Patuxent Sewer from the Little Patuxent Water Reclamation Plant near Savage, Maryland extending north to an existing pumping station in close proximity to Maryland Route 108 for a total of approximately 55,000 linear feet (10.4 miles) through the towns of Savage, Guilford, and Columbia. A Site Location Map showing the extent and approximate alignment of the Little Patuxent Parallel Sewer Interceptor (LPPSI) is enclosed as Attachment 1 to this report.

The selected alignment will deviate from a strict parallel alignment only in areas where a parallel sewer is not feasible due to existing infrastructure, historic/cultural, or natural resource constraints. In general, where the proposed LPPSI would parallel the existing sewer, HODPW would acquire an additional 20-foot utility easement plus a 10-foot temporary construction easement, also known as a construction strip alongside the existing easement. This additional construction strip will not generally be cleared of vegetation, but would be used to facilitate the movement and storage of equipment within the construction site. In areas where a parallel alignment is not possible, HODPW would acquire a new 40-foot easement plus a 10-foot construction strip to facilitate construction activities.

Temporary and permanent impacts to waters of the United States (WUS), including jurisdictional wetlands, regulated buffers and the 100-year floodplain are considered unavoidable in order to construct the LPPSI. The Little Patuxent River and its tributaries in this vicinity have a

Maryland Surface Water Designation of Use I-P, pursuant to which they are protected for Water Contact Recreation, Protection of Aquatic Life and Public Water Supply (COMAR 26.08.02).

HODPW intends to develop, in coordination with the Maryland Department of the Environment (MDE) and U.S. Army Corps of Engineers (USACE), a mitigation package to adequately compensate for project-related permanent impacts to natural resources. In accordance with the Maryland Compensatory Mitigation Guidance developed by the Interagency Mitigation Task Force (1994), an applicant must complete a series of steps in order to properly account for and mitigate unavoidable impacts to regulated natural resources. These steps include:

- Identifying the area and type of wetland resource affected by the project;
- Conducting a project site and design alternatives analysis (avoidance and minimization);
- Qualifying the functions and values of the affected resources;
- Developing a compensatory mitigation plan to account for lost functions and values.

This letter report will supplement information provided previously with the August 2007 Joint Federal/State Application for the overall sewer installation activity. As such, some of the material included below has been provided previously but is described here in an abbreviated manner to allow for a concise review and approval of the enclosed mitigation plan.

## Description of Wetland /Waterway Resources and Proposed Impacts

Extensive wetland delineation fieldwork was conducted during the fall of 2005 and again during the spring of 2007 to adequately describe wetland and waterway resources within the LPPSI project corridor. The results of these delineation efforts are presented within the Wetland Delineation Report for the Little Patuxent Parallel Sewer (December 2005) and the subsequent Wetland Delineation Report Addendum (July 2007) prepared by KCI Technologies, Inc. (KCI). Copies of these reports were included with the submission of a Joint Federal/State Permit Application package during August 2007. In addition to the delineation of wetlands and waterways, these reports included a detailed assessment of the functions and values of wetland systems following USACE's Highway Methodology Workbook Supplement, Wetland Functions and Values, a Descriptive Approach (1995), also known as the "New England Method". A brief synopsis of regulated resources is included below.

### *Nontidal Wetlands and Waterways*

In general, palustrine forested, scrub-shrub, and emergent wetlands and tributary riverine systems associated with the Little Patuxent River were observed within the study area. The character and function of wetland systems within the corridor is generally determined by their location in the project corridor. For the purposes of describing the composition of regulated resources, the 10.5-mile study area can be divided into three distinct segments, defined herein as Segments A, B, and C, as described below.

Segment A Wetlands and Streams

Segment A is located between the Little Patuxent Water Reclamation Plant and Guilford Road. The southernmost portion of Segment A, from the reclamation plant to approximately US Route 1, is located in the Coastal Plain Physiographic Province. The remainder of Segment A, from US Route 1 to Guilford Road, is best characterized as having "Fall Line" characteristics, making the transition from Coastal Plain to Piedmont Physiographic Province. The topography of Segment A is flat to gently sloping in the Coastal Plain but abruptly becomes moderately to steeply sloping above US Route 1.

Land use encroachment and geomorphology have limited wetland development to small areas in the narrow floodplain and groundwater discharge areas typical of a bedrock stream valley. Vegetative cover is predominantly mature forest, with sycamore (*Platanus occidentalis*) and American beech (*Fagus grandifolia*) as dominant species. Functions of wetland systems delineated within Segment A of the study corridor include groundwater discharge, flood flow alteration, sediment and toxicant retention, nutrient removal, wildlife habitat, and production export.

Segment A includes perennial, intermittent, and ephemeral waterways. The Little Patuxent River is the dominant perennial waterway of Segment A and of the entire study area overall. Perennial tributaries of the Little Patuxent River are also found in the vicinity of Guilford Road and Broken Land Parkway. Intermittent streams were found draining groundwater seeps, riparian wetlands, and abandoned stormwater management or sediment control facilities in floodplain areas throughout Segment A of the study corridor.

Segment B Wetlands and Streams

Segment B begins in the vicinity of Guilford Road and extends north to the upstream end of Lake Kittamaqundi in Columbia. Segment B is located in the Piedmont Physiographic Province since the study corridor area has crossed the transition from Coastal Plain to Piedmont Physiographic Province via the "Fall Line". The topography of Segment B varies from gently sloping to moderately sloping.

Wetlands found within Segment B are characterized by 1) increased species homogeneity in comparison to wetland systems found in Segment A due to increased uniformity of topography, floodplain cross-section, and hydrology source and 2) forested areas dominated by monotypic stands of box-elder (*Acer negundo*). The corridor contains palustrine forested and palustrine emergent wetland systems.

The functions and values of wetland systems delineated within Segment B of the study corridor included sediment and toxicant retention, groundwater discharge, wildlife habitat, nutrient removal, production transport, flood flow alteration, visual quality and aesthetics, stormwater storage, and sediment and shoreline stabilization.

Waterways delineated in the lower portion of Segment B consisted mainly of ephemeral drainage channels deriving hydrology from storm runoff originating in residential developments. Perennial and intermittent waterways were found in the vicinity of the US Route 29 (Columbia

Pike) and Broken Land Parkway interchange. The drainage areas of these systems are generally located west of US Route 29; surrounding land use within these drainage areas is mixed, consisting of residential and commercial development, schools, and open space.

Segment C Wetlands and Streams

Segment C begins at the upstream (northernmost) end of Lake Kittamaqundi and ends south of MD Route 108. Segment C is located in the Piedmont Physiographic Province, with topography within undisturbed areas of the corridor varies from gently sloping to moderately sloping. The floodplain cross-section varies greatly in width and has been altered by past highway and golf course construction as well as commercial and residential development. The soil profile is intact except in areas of prior development, as described above. Land uses in Segment C have had varied impacts on the riparian floodplain systems within this segment of the project corridor. Low-density development in the area has lead to a reduction of impervious surfaces immediately adjacent to the study area. Highway construction and high-density land development has occurred in the tributary drainage areas east of US Route 29 and accounts for increased impervious surfaces in this area.

Notable vegetation characteristics within Segment C include, 1) a greater increase in species homogeneity in comparison to wetland systems found in both Segments A and B due to land disturbance and landscape management, and 2) an abrupt disappearance of box elder dominated forest, with red maple (*Acer rubrum*) now dominating the canopy. The corridor contains palustrine forested and palustrine emergent wetlands, similar to the other segments described above, but systems vary in vegetative composition and size.

Functions and values associated with wetland systems found in Segment C include groundwater discharge, fish and shellfish habitat, sediment and toxicant retention, nutrient removal, production export, wildlife habitat, recreation, educational scientific value, uniqueness and heritage, visual quality and aesthetics, stormwater storage.

Waterways found in Segment C of the study area were mainly perennial systems having drainage areas extending to the east of US Route 29.

***Description of Anticipated Impacts to Regulated Resources***

The overwhelming majority of project-related impacts to regulated resources would be considered temporary in nature, resulting from vehicular access through the project area, construction access and parallel sewer installation activities. Permanent impacts would result from the conversion of existing palustrine forested (PFO) wetlands to palustrine emergent (PEM) wetlands resulting from the clearing of new easement area adjacent to the existing utility easement. Permanent impacts to regulated WUS would result from the placement of stone stabilization measures within the channel at select utility crossings and in the form of bank stabilization in areas susceptible to bank erosion. Additional information related to impacts to regulated Waters of the U.S., including jurisdictional wetlands and the 100-year floodplain is included in tabular form below.

| Regulated Resource Impact Type | Impact Area | | |
|---|---|---|---|
| | SF | AC | LF |
| Temporary Nontidal Wetland Impact | 93,000 sf | 2.13 ac | |
| Temporary Buffer Impact | 303,489 sf | 6.97 ac. | |
| Temporary 100-Year Floodplain Impact | 2,636,062 sf | 60.52 ac. | |
| Temporary Length of Stream Affected | 78,981 sf | 1.81 ac. | 6,952 lf |
| Permanent Nontidal Wetland Impact | 120,019 sf | 2.76 ac. | |
| Permanent 100-Year Floodplain Impact | 0.0 sf | 0.0 ac. | |
| Permanent Length of Stream Affected | 11,470 sf | 0.263 ac. | 597 lf |

**Project Site and Design Alternatives Analysis (Avoidance and Minimization)**

The majority of project-related impacts to regulated resources would be considered temporary in nature, but permanent impacts would occur due to the "conversion" of wetlands (forested to emergent) for new easement area and the placement of stone stabilization within waterways at select utility crossings. HODPW has made every attempt to minimize and avoid impacts to sensitive environmental features along the project corridor.

In general, easement areas are to be kept as narrow as possible to minimize impacts to regulated features. Based on current design guidance for utility lines of this size, HODPW would usually seek a minimum easement of 45-feet, with two 10-foot construction strips to provide ample space for the installation of the utility. For this particular project, and due to the sensitive natural environment surrounding the project, HODPW will only acquire an additional 20-foot utility easement plus a 10-foot construction strip alongside the existing easement. In areas where a parallel alignment is not possible, HODPW would acquire a new 40-foot easement plus one 10-foot construction strip to facilitate construction activities.

In addition to this reduced limit of disturbance, to minimize erosion and sedimentation within the stream valley the proposed LPPSI will be installed on the opposite side of the existing sewer interceptor from the main stem of the Little Patuxent River and, to the extent possible, at a distance exceeding 25-feet from the adjacent stream channel. This will not be possible over the entire 55,000-foot alignment due to design and/or engineering constraints and, in those instances, justification will be provided in the future. Specifically, maintenance of the 25-foot buffer will not be feasible in the area of the Historic Savage Dam ruins due to their close proximity to the Little Patuxent River and the fact that the trenchless technology required to install the line in this area within 25 feet of the existing line could compromise the historic structures. Further, the installation on the landward side of the ruins would require significant excavation and could also compromise the historic structures.

Additional information concerning avoidance and minimization measures, including a full review of project alignment alternatives was included with the August 2007 Joint Federal/State Permit Application. Additional refinement of proposed impacts continues as the project design advances. This additional avoidance and minimization analysis will be presented in conjunction with final plans by phase.

## Functions and Values of Impacted Systems

Of the functions and values described by the Highway Methodology Workbook Supplement, Wetland Functions and Values, a Descriptive Approach (USACE 1995), the following functions are present in the nontidal wetland resources occurring within the proposed LPPSI project corridor:

- Groundwater Recharge / Discharge;
- Flood Flow Alteration (Storage and Desynchronization);
- Fish and Shellfish Habitat;
- Sediment / Toxicant / Pathogen Retention;
- Nutrient Removal / Retention / Transformation; Production Export (Nutrient);
- Sediment / Shoreline Stabilization, and;
- Wildlife Habitat.

Further, the values associated with project corridor wetlands include:

- Recreation;
- Educational / Scientific Value;
- Uniqueness / Heritage, and;
- Visual Quality / Aesthetics.

The majority of these functions and values would not be permanently altered as a result of the proposed LPPSI project. Specifically, the project site would be returned to pre-construction conditions once work efforts are completed with the exception of the new easement area that would be cleared of woody vegetation and replaced with herbaceous (emergent) vegetation only. This is necessary as tap roots from large trees could compromise the sewer line and heavy bush or trees would impede any maintenance or repair activities that may be necessary in the future.

Of the functions and values found within the project corridor, those most likely to be impacted by the conversion of forested wetlands to emergent wetlands would be:

- Sediment / Toxicant / Pathogen Retention;
- Nutrient Removal / Retention / Transformation; Production Export (Nutrient);
- Sediment / Shoreline Stabilization;
- Wildlife Habitat, and;
- Visual Quality / Aesthetics.

Therefore, a mitigation plan for this project must serve to replace, or in this case, enhance the functions and values modified as a result of this project.

## Compensatory Mitigation Plan

HODPW is currently investigating mitigation options within the study area that would benefit the natural environment in close proximity to the LPPSI project area. Based on extensive field investigations between September 2005 and the present, several areas were identified as having

the potential for mitigation related to this project. These areas have been reviewed by KCI, HODPW and the regulatory agencies at various times over the course of the project.

To compensate for the conversion of existing palustrine forested wetlands to emergent systems and the functions and values modified as a result of construction activities within these areas, HODPW proposes the enhancement of an existing wetland/upland complex located immediately adjacent to the sewer installation project area in the vicinity of Leaftreader Way, to the south of MD 175 in Columbia. This site, herein referred to as the Leaftreader Way Mitigation Site, was discussed as a feasible site for compensation of wetland impacts during a November 2007 field investigation with MDE and KCI personnel.

Based on preliminary field reconnaissance for the study area performed during the spring and summer of 2007 by KCI, it was determined that restoration and rehabilitation of stream systems, including the main stem Little Patuxent River, within Contract Areas 7 and 8 could prove to be particularly beneficial to the surrounding natural environment and therefore these areas would be the focus for stream mitigation within the project corridor. Among other factors, soil type and surrounding development in the vicinity have facilitated extensive erosion within the stream valley to an extent not observed throughout the lowermost reaches of the project (Segment A and portions of Segment B).

Attachment 2 shows the locations of the proposed mitigation sites in relation to the LPPSI project corridor.

***Wetland Creation, Enhancement and Invasive Species Management: Leaftreader Way Site***

The Leaftreader Way Mitigation Site represents one of the largest wetland/upland complexes in the surrounding area, and, as a result, should be the target of enhancement activities to preserve and enhance the Uniqueness /Heritage value of the site. Further, with minor improvements in the species composition on the subject parcel, combined with the modification of remnant agricultural ditches on the site, it can be expected that this site would attract more diverse wildlife.

As such, HODPW proposes a plan to create additional wetland acreage on the site, eradicate invasive and monotypic species, modify on-site hydrology by the plugging of historic agricultural ditches on the site, and the development of a diverse planting schedule within the site.

Prior to the commencement of field surveys at the Leaftreader Mitigation Site, KCI reviewed readily available information regarding the study area. References used in this review are included as Appendix F to this report. Preliminary field reconnaissance for this parcel was conducted during November 2007 with regulatory (MDE) personnel present.

<u>Preliminary Data Review for the Leaftreader Mitigation Site</u>

Parcel 463/196 (Open Space Lot 1) is an approximately 66-acre parcel of land owned by Columbia Association and managed as “Open Space”. This roughly triangular parcel is bounded

to the north by MD 175 and on-ramps, US Route 29 to the east, additional Open Space lots to the south, and the Little Patuxent River and residential development to the west.

Open Space Lot 1 is located within the 100-year floodplain associated with the Little Patuxent River (Watershed Segment 02-13-11-05). Land uses to the west of the subject site are predominantly residential in nature, with additional open space uses to the south. Land use within the study area is currently designated as "Deciduous Forest" (Code 41), although portions of open canopy are visible from existing aerial photography. The parcel is currently designated as Columbia Association "Open Space".

*Land Use and Topography*

The study area is within the Upland Section of the Piedmont Plateau Physiographic province. Based on review of the Savage, Maryland 7.5' USGS Topographic Quadrangle Maps and other readily available sources, the average elevation of this portion of the study area is approximately 306 feet above MSL. Within this area there is micro topography with depressional pockets throughout. Copies of the relevant USGS quadrangles are enclosed as Attachment 3 to this report.

*Soils*

According to the Countywide Soils Map of Howard County (NRCS, 2003), the Leaftreader Mitigation Site is located within the Glenelg-Manor-Chester Soil Association. Within this association, the following individual soil units were identified on the project site:

- Hatboro-Codorus silt loams, 0 to 3 percent slopes (Ha);
- Manor loam, 8 to 15 percent slopes (MaC);
- Glenville-Codorus Silt Loams, 0 to 8 percent slopes (GoB), and;
- Baile Silt Loam, 0 to 3 percent slopes (BaA).

Of the units identified within the parcel, the Hatboro-Codorus silt loam (Ha) and the Baile silt loam units are listed as hydric soils. Hydric soils are defined as those soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part of the soil profile. Classification of mapped soil units as hydric soils is based on the Hydric Soils list for Howard County, Maryland found in the Natural Resources Conservation Service Web Soil Survey (available online). Locations of soil units in relation to the project site are shown in Attachment 3 to this report.

*National Wetlands Inventory Mapping*

U.S. Fish and Wildlife Service (USFWS), National Wetland Inventory (NWI) Savage, Maryland Quadrangle indicates the presence of NWI-classified waters and wetlands in the vicinity of the study area (USFWS 1981). Specifically, existing mapping shows the subject site as having the following wetland systems present:

- Palustrine, forested, broad-leaved deciduous, temporarily flooded (PFO1A);

- Palustrine, scrub-shrub, broad-leaved deciduous/emergent, narrow-leaved persistent, temporary (PSS1/EM5A); and,
- Riverine, lower perennial, open water, permanent (R2OWH).

Locations of NWI-classified wetlands within and in close proximity to the study area are shown on Attachment 3.

*FEMA-Designated Floodplains*

According to a review of Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps, the study area lies almost entirely within the 100-year floodplain of the Little Patuxent River and its tributaries as mapped (FEMA Q3 Flood Data 1986). Areas of 100-year floodplain within the study area are included as Attachment 3 to this report.

Review of Historic Aerial Photography

The Howard County Department of Planning and Zoning (HODPZ) maintains a collection of historic aerial photographs for various locations within the county dating from 1957 through 1984. This collection was reviewed prior to the development of a conceptual mitigation plan to determine if any past disturbance had occurred on the Leaftreader Way Mitigation Site. Information obtained from this review was instrumental in the development of a mitigation plan for the site. Copies of these historic aerial photographs are included as Attachment 4 to this report.

*1957 Aerial Photograph*

The 1957 aerial photograph shows the subject site prior to the development of the Columbia Town Center or other major residential or commercial uses in the area. A roadway bisects the parcel beginning at US Route 29 in the east and progressing west across the Little Patuxent River. The northern portion of the site is sparsely vegetated with very little understory visible. The southernmost portion of the site is shown in agricultural use (possibly pasture), with a constructed drainage ditch running north to south through the subject parcel. This drainage ditch continues to the north of the roadway into the sparsely forested area. This photograph represents the earliest available aerial image of the subject parcel, and, as such, it is not known when the parcel was first cleared for agricultural uses.

There is evidence of stream channelization of the Little Patuxent River throughout this area, with remnant, unconnected stream meanders visible within the subject site and also further to the south beyond the limits of study.

*1963 Aerial Photograph*

A review of the 1963 aerial photograph shows the southern extent of the parcel occupied with agricultural uses, possibly a row crop such as corn. The northern extent of the subject site appears to have a well-developed canopy, as does the southernmost extent beyond the area in agricultural production. The drainage ditch is still visible within the subject site, with an adjacent hedgerow visible in the photograph.

Wide scale development has not encroached on this area as of the 1963 photograph. Those areas that appear to be somewhat sparsely vegetated in the 1957 aerial photo appear to be more densely vegetated in the 1963 photograph.

*1980 Aerial Photograph*

The 1980 aerial photograph shows the development associated with Columbia Town Center and other residential uses, as well as the creation of Lake Kittamaqundi and Wilde Lake in close proximity to the Leaftreader site. Further, the 1980 aerial photograph shows the development of MD Route 175 (the Little Patuxent Parkway) as the primary road into the Columbia Town Center, with a major interchange with US Route 29 to the northeast of the subject site. The existing roadbed bisecting the site is still visible, but appears to be abandoned.

Development has occurred on adjacent lands and agricultural uses on the subject parcel have ceased. The subject site appears to be returning to a more natural state, with woody vegetation present within the northern and southernmost extents of the parcel. A large area in the approximate center of the site is not vegetated (or sparsely vegetated). The drainage ditch used to maintain the site in agricultural production is still visible through the site.

*1984 Aerial Photograph*

The 1984 aerial photograph shows a major portion of the surrounding area developed, with both residential and commercial uses dominating the landscape. A golf course, Fairway Hills Golf Course, occupies a large tract of land previously in agriculture to the north of the subject site. The subject site is predominantly wooded, with an open/emergent section visible within the center of the parcel.

It appears as if some type of disturbance besides agricultural uses has kept the center of the subject site from re-vegetating similar to the surrounding area. The cause of this disturbance was undetermined based on the review of aerial photography, but detailed field investigation conducted during November 2007 would reveal a possible cause.

<u>November 2007 Field Investigation</u>

On-site investigations were conducted during November 2007. This included the delineation of wetlands and waterways within the subject parcel in accordance with USACE (1987) methodologies, a survey of existing vegetative communities on the subject site, and a general site walk to identity potential areas for wetland creation and/or enhancement within the northern portion of the subject site. In general, field investigations verified the information gathered during the literature review, with minor exceptions. A current aerial photograph of the subject site showing the field-verified conditions described below is included as Attachment 5 to this report. The southernmost extent of this parcel was not investigated further for mitigation potential since mature, forested wetlands dominate this portion of the subject site and prior disturbances were not found on the review of historic aerial photography in this area.

The majority of the parcel to the north of the abandoned roadbed is currently forested, with mature red maple (*Acer rubrum*), and various oaks (*Quercus*) species dominating. Forest cover changes to the south of the abandoned roadbed, with a mixed vegetative community consisting of black willow (*Salix nigra*) in the scrub-shrub area and red maple and various oaks in the forested areas. The center of the site is occupied by a large emergent area dominated by a generally monotypic stand of reed canary grass (*Phalaris arundinacea*). The reed canary grass stand is approximately 4.35 acres in size, with few other species breaking through this dense mat to survive on the site. In addition to the monotypic stand of reed canary grass, two other areas are overrun with common reed (*Phragmites australis*) and broad-leaf cattail (*Typha latifolia*). These monotypic stands occupy approximately 0.25 and 1.5 acres, respectively.

A large palustrine forested wetland is located to the north of the abandoned roadbed. This system occupies approximately 4.1 acres and is bounded by the edge of fill material for the MD 175 on-ramp to the east. In the west, this wetland is bordered by the proposed LPPSI project area and would not be impacted as a result of installation activities. Red maple, pin oak (*Quercus palustris*) and box elder dominate the canopy layer. Spicebush (*Lindera benzoin*), and box elder dominate the understory. In areas where herbaceous cover is present, this layer consists predominantly of small patches of stout wood-reedgrass (*Cinna arundinacea*).

The portion of the subject site to the south of the abandoned roadbed is dominated by a large forested/scrub-shrub/emergent wetland with upland areas to the east of this system near US Route 29. The wetland within this portion of the study site is approximately 13.4 acres in size.

In total, the roadbed extends for approximately 1,050 feet from the dead end at Leaftreader Way in the west to the embankment of the MD Route 175 on-ramp in the east. The roadbed to the east of the river is currently in disrepair, with potholes and evidence of erosion along its entire length. Appendix A includes photographs of the subject site and, specifically, the abandoned roadbed, taken during the November 2007 field investigation. This roadbed currently separates the two large palustrine wetland systems described above, as shown on Attachment 5. In general, these wetland systems extend to the edge of fill for the roadbed and, as such, were most likely connected prior to the development of the road.

Field investigations also located the remnant agricultural drainage ditch running generally north to south through the subject site. The ditch begins to the north of the abandoned roadbed, extends beneath the road through a corrugated metal pipe and continues south into the scrub-shrub/emergent portion of the site. This ditch loses definition within a dense stand of cattails in the approximate center of the subject site, but small outlet channels continue beyond the cattail stand to a connection with a minor perennial stream in the south.

In addition, KCI observed the remnant channel meanders of the Little Patuxent River within the subject site as they existed prior to the channelization of the Little Patuxent River sometime in the last century. These meanders appear as low-lying areas within the southwestern portion of the study area and are completely vegetated. These meanders are not currently connected to the main stem Little Patuxent River; instead, they are a low spot within the site and accumulate standing water at various times throughout the year.

Proposed Conceptual Plan: Leaftreader Way Mitigation Site

Based on the review of readily available aerial photography, combined with detailed field investigations, HODPW proposes the following work plan to compensate for wetland impacts associated within the sewer line installation. This site is currently functioning as a wetland but has potential for:

- The creation of additional wetland acreage by the removal of an existing roadbed that bisects the site, thereby connecting two larger wetland systems;
- Overall site enhancement by the management of invasive and monotypic vegetative communities (*Phragmites australis* and *Typha latifolia*, respectively);
- The modification of historic agricultural drainage "ditches" to restore the site's historic hydrologic regime, and;
- The development of a comprehensive planting schedule for the site once the invasive species are under control and other modifications have been implemented.

Additional information related to the location and size of the abovementioned treatments is included below and shown on Appendix B to this report.

*Wetland Creation Area: Approx. 0.71 Acres*

The creation of additional wetland area would be accomplished through the removal of approximately 560 linear feet of the abandoned roadbed, including all fill and sub-grade material associated with the road. In addition, minor grading of adjacent areas would be required to maintain consistent grade between the two large forested wetland areas to allow for the conveyance of surface hydrology between these areas. The approximate limits of work associated with this effort are shown on Attachment B to this report. In total, approximately 0.71 acres of wetland area would be created by removing this portion of the roadbed.

*Modification of Remnant Drainage Ditches: Approx. 325 Linear Feet*

The existing (historic) agricultural ditches on the subject site currently serve to drain the large palustrine wetlands. This is especially true within the southernmost portion of the study area, where a remnant ditch feature has a connection to a perennial waterway.

The use of bentonite clay or other suitable material at the downstream-most end of the drainage ditch will be employed to ensure that the flow in this channel remains within the wetland area and that the hydrology previously moved through and off of the subject site will provide for extended periods of ponding within some areas of the site. The approximate limits of work associated with this effort are shown on Attachment B to this report. Pending the review of hydrologic data for the site, it is possible that shallow water habitat could be present for extended periods of time allowing the site to be of benefit for resident and migratory waterfowl.

*Invasive and Monoculture Species Management: Approx. 6.1 Acres*

HODPW will develop a plan for the control and future management of common reed and broad-leaf cattail on the subject site in order to restore a more diverse herbaceous and scrub-shrub plant community to the site. These control measures will be a combination of mechanized control techniques and herbicidal techniques, as controlled burns would most likely not be feasible given the location in a highly urbanized setting. In total, approximately 0.25 acres f common reed would be eliminated from the subject site, along with 1.5 acres of broad-leaf cattail monocultures and a 4.35 acre patch of reed canary grass. The approximate limits of work associated with this effort are shown on Attachment B to this report.

Site investigations determined that the three species mentioned above are serving to limit the potential diversity of the subject site. By developing and implementing a management plan, it is expected that a more diverse plant community would occupy the subject site, thereby making the site more attractive t a wider range of wildlife.

*Comprehensive Planting Schedule: Approx. 6.8 Acres*

Once the invasive species controls have been established, a comprehensive plating schedule better matched to the site's hydrologic regime will be implemented. This will include the development of scrub-shrub and forested wetland planting zones, the size and extent of which will depend on additional field analysis to determine the best hydrologic zonation on the site. In general, it is most likely possible that the majority of 4.35 acres formerly occupied with reed canary grass would be retuned to a forested wetland via planting, while those areas holding more surface water during the growing season will be used to develop unique, biologically diverse emergent and scrub-shrub areas. The outline of these zones, and transitions between them will be better described in subsequent documents once the Phase I mitigation plan has been approved. In total, approximately 6.8 acres will be planted on the Leaftreader Way Mitigation Site, including the area cleared of monotypic vegetation and the area cleared for wetland creation in the vicinity of the existing roadbed.

***Stream Stabilization and Restoration: Downstream of Stevens Forest Road***

Based on this initial assessment and field walk with HODPW personnel, KCI evaluated two study reaches, Site A and Site B, encompassing approximately 1,000 linear feet of stream channel centered on existing Manholes 1357 and 1334, respectively, from south of Stevens Forest Road and Broken Land Parkway in the north and extending south to Patuxent Woods Drive near MD Route 32.

As part of this effort, KCI conducted a preliminary literature review and conducted a cursory visual geomorphic assessment of the study area prior to the initiation of a detailed fluvial geomorphic assessment. Once the visual observation was completed, KCI conducted a detailed fluvial geomorphic assessment consisting of the survey of the longitudinal profile and cross-sections, assessing stream bank conditions, planform and collecting and analyzing sediment. The data collected in the geomorphic assessment was used to identify the unstable areas of the channel and determine the cause(s) of instability. A stream restoration concept was developed to address the unstable areas of the channel and, to the extent possible, correct the causes.

The complete results of this investigation are presented within the Little Patuxent Stream Bank Stabilization Project, Concept Design Report (November 2007). KCI and HODPW reviewed the information presented in this report during December 2007 and those conceptual plans with the most mitigation potential are presented in this current report for regulatory agency review and approval.

Visual Assessment

Stream restoration specialists conducted a visual geomorphic assessment of a 9,000 linear foot study reach of the Little Patuxent River from Stevens Forest Road downstream to the foot bridge near Patuxent Woods Drive. The visual assessment revealed areas of concern and an understanding of the processes influencing the system. Refer to Attachment 6 of this report for mapping showing the results of this visual assessment. The stationing used in this description to distinguish the location of observed features is approximate and based on station 0+00 beginning at the crossing with Stevens Forest Road and increases in the downstream direction. This stationing has been estimated for the discussion of observations and is represented on Attachment 6 and does not reflect the longitudinal profile survey stationing.

Within the study reach, the Little Patuxent River is situated in a broad (typically 400 to 500 feet wide with localized constrictions) alluvial valley with a mature riparian forest. This valley corresponds to a stream valley type VIII and is typified as having a wide valley and well developed floodplain with a gentle valley slope (Rosgen 1996). The floodplain soils are uniform and representative of reworked alluvium with a stratified clay layer defining the toe of bank. Recent deposits of fine grained alluvium (sand and silt) were observed on the floodplain indicating active processes.

The underlying geology of the Little Patuxent River in the location of the study reach provides periodic grade control in the form of boulder outcrops that occur intermittently throughout the reach. The channel slope is uniform and flat (<0.5%) throughout the reach with localized knick points at boulder outcrops and sewer crossings. The presence of these grade controls throughout the reach limits the potential for the channel to incise.

In several locations, rooted tree stumps were observed in the channel bed. These stumps indicate the existence of a relic depositional surface (channel floodplain or bar top) that occurred in the river's history. Within this region, this relic surface is commonly the pre-settlement surface and the modern surface is the result of a period of sedimentation and rapid floodplain accretion caused by the intense land clearing and agriculture that occurred from the early 1800s to around 1940 (Jacobson and Coleman 1986). Consequently, stream channels that were once perched on this recent alluvium, are now incising and widening. Based on the exposed boulder outcrops providing grade control, it is assumed that the Little Patuxent River has undergone the channel incision phase and is actively widening; consequently exposing buried woody debris.

Generally, the stream bank heights are between 7 and 10 feet and overall the bank shape is curved with lower bank angles at the toe of slope and increasing nearly vertical in the upper third of the bank. The lower angle at the toe of bank indicates the presence of a relatively resistant

clay material. The stream banks throughout the reach were generally devoid of vegetation and/or surface protection.

Overall the stream is relatively straight (sinuosity <1.2) with long shallow meanders. In several locations irregular and compressed meanders result from localized geology or perturbations. Both Sites A and B occur within areas of irregular meander geometry where the natural process of meander migration has caused the Little Patuxent River to come into conflict with existing sewer infrastructure.

In addition to the reach wide observations, the following specific observations were recorded during the assessment:

- Station 0+00 to 8+00: A stratified clay lens acting as grade control was observed on the lower one-third of the bank. Within this region little to no vegetation is located on the banks leaving them susceptible to further erosion. Additionally, the bed material consists primarily of sand and silt.

- Station 7+00 to 10+00: Active meander migration resulting from a significant debris jam at station 10+00 at the beginning of Site A. The debris jam caused the channel to avulse upstream and initiated the migration. As a result the compound meander located downstream of the debris jam is anticipated to expand and migrate toward Manhole 1357 and the interceptor sewer line.

- Station 8+00 to 14+00: The bed materials begin to change further downstream between the stations of 8+00 through 14+00 from sand and silt to gravel and cobble.

- Station 27+00 to 30+00: The stream valley constricts to nearly half the typical valley width.

- Stations 15+00, 40+50, 80+00, and 90+00: Fish blockages were caused by the sanitary sewer crossing with both depth and height barriers observed.

- Downstream of Station 35+00: The channel bed material changes from boulders and fine material to predominately gravel and sand.

- Station 39+00 to 40+00: The channel narrows relative to the rest of the reach as a result of riprap along the stream banks and then begins to widen again downstream of station 40+00. Additional grade control features observed in this region include rock outcrops and clay lenses at the banks. Within this region the banks continue to have minimal vegetation.

- Downstream of Station 75+00: Debris jams become more frequent within the channel and the valley begins to widen.

- Downstream of Station 80+00: A series of actively migrating compressed meanders formed as a result of the Lake Elkhorn Tributary. This region includes Site B and has

potential for further meander migration which may expose additional sewer infrastructure.

- Station 90+00: Active meander migration is occurring in the vicinity of Manhole 1334 and the existing interceptor sewer is exposed creating a fish blockage.

- Station 95+00: Active meander migration occurs within this bend.

Detailed Geomorphic Assessment

*Site A Assessment Results*

Site A contains a compound loop (consisting of two consecutive left meanders with a short tangent between) meander bend and has an overall channel bed slope of 0.15%. Debris dams and boulder outcrops are the dominate channel roughness features and were observed at various locations during the collection of data.

The results of the pebble count indicate a $D_{50}$ of 4.6 mm (fine gravel) and a $D_{84}$ of 64mm (very coarse gravel to small cobble). The threshold grain size (d) is 11 mm (medium gravel). Since the threshold grain size is greater than the $D_{50}$ and less than the $D_{84}$, the channel bed is likely to be vertically stable. Additional influences on the streams vertical stability throughout Site A are the boulder outcrop and down stream sewer line crossings discussed in the longitudinal profile.

The average radius of curvature for meander bends in the vicinity of Site A is 141 feet with an R: W ratio of 3.2. This indicates that the meanders are susceptible to future migration as supported by the other assessments. The channel sinuosity for Site A is 1.3 indicating that the reach is relatively straight with the exception of the compound loop meander.

The results of the geomorphic assessment conducted throughout Site A indicate that the channel is unstable. Both channel cross-sections were widening and the active channel meander migration was documented with in the reach. Within Site A, both geologic and anthropogenic grade controls have restricted further channel incision. It is anticipated that the sewer infrastructure will be exposed by these processes. To determine the rate at which these processes are occurring would and potential impact on the sewer infrastructure would require continued monitoring of the site.

Refer to Attachment 7 of this report for the locations of the detailed geomorphic assessment within Stream Study Site A.

*Site B Assessment Results*

Site B is characterized by a sinuous channel with actively eroding banks. The overall channel bed slope is 0.13%. There are two tributaries entering this system.

The results of the pebble count indicate a $D_{50}$ of 0.27 mm (medium sand) and a $D_{84}$ of 14 mm (medium gravel). The threshold grain size is 17 mm (coarse gravel). Since the threshold grain size is greater than both the $D_{50}$ and the $D_{84}$, the channel bed is unstable and susceptible to

further degradation. Geologic controls were not observed throughout Site B as they were in Site A, therefore both bed scour and channel incision are potential concerns.

The average radius of curvature for meander bends in the vicinity of Site B is 76 feet with an R:W ratio of 1.8. This indicates that the meanders are actively migrating and are unstable, both are conclusions supported by the other assessments. The channel sinuosity for Site B is 1.8 indicating that the reach is sinuous. The sinuosity is controlling the channel slope locally, which reduces the potential for bed scour. As meanders adjust within the reach, the channel slope will increase locally and further incision will occur.

Site B is a sinuous reach that is currently adjusting as the active processes of channel widening, meander migration, and channel incision work through the system. Site B lacks the geologic grade controls of Site A and the stream is able to mobilize the sediments supplied by the current conditions of its watershed. Due to the observed active channel process occurring throughout the reach, it is anticipated the channel will continue to degrade. The channel degradation has significant potential to undermine the existing interceptor sewer and expose the parallel sewer.

Refer to Attachment 7 of this report for the locations of the detailed geomorphic assessment within Stream Study Site B.

Proposed Conceptual Plans: Site A and Site B

Using the data and analysis for the fluvial geomorphic assessments and the hydrology and the hydraulics study performed previously for this area, KCI applied a hierarchal approach presented by Rosgen (1997) and summarized below to develop the restoration concepts.

- Priority 1: Restore the channel at the historical floodplain;
- Priority 2: Restore the channel at the present elevation;
- Priority 3: Widen the channel at the existing bankfull elevation, and;
- Priority 4: Stabilize the streambed and banks in place.

Based on the potential encroachment of the 100-year floodplain on private properties and the feasibility of transitioning the channel back to the existing channel, Priority 1 restorations were not considered for either site. A combination of Priority 2, 3 and 4 was determined to best achieve the restoration goals for Sites A and B. A major emphasis was placed on a Priority 4 approach based on constructability (LOD, cost / benefit, permits, and clients needs).

Two restoration concepts, hereinafter called “options”, have been designed for Site A and three options have been investigated for Site B. While each has been designed to meet the overall project goals; the degree of ecological impacts, forest impacts, and overall cost and long term success will vary. Option 1 in both instances is a Priority 4 approach that focuses primarily on armoring the existing channel bed and banks as necessary to arrest the active channel processes discussed previously. Option 2 in both sites will parallel a Priority 3 approach which recognizes the causes of instability and proposes minor channel realignment and structure to protect

infrastructure; and Option 3 at Site B will be a Priority 2 restoration that proposes major channel realignment. Narrative descriptions of the proposed concepts are presented in the following sections and plan sheets depicting a generalized concept, limits of grading and disturbance, and proposed access are presented in Appendix C and D to this report for Site A and B, respectively.

*Site A*

Based on the geomorphic assessment, the primary problems that could potentially affect the area include the migration of the compound loop meander that the sewer parallels in addition to the continued channel widening. Both of these problems have potential to expose the existing and proposed sewer line infrastructure. Due to the presence of natural grade control, channel incision is not anticipated to affect the sewer line infrastructure within this reach. The following options address these conditions.

*Site A, Option 1*

Option 1 proposes to armor the entire length of the meander which has potential to erode with stone so that has the ability to resist the erosive forces of the flow. To accomplish this, the bank stabilization will need to encroach on the channel to some extent to achieve the appropriate cover on the sewer lines. As a result of the encroachment some bank grading on the opposing bank may be necessary to increase the channel capacity so that the project has a minimal impact on the 100-year WSEL. The top of the bank stabilization will be set at an elevation necessary to tie-in to existing grade at a maximum slope of 2:1 and achieve the desired cover over the sewer lines. At the toe of the bank, the scour depth will need to be determined due to the stream forces that were once dissipated by eroding the bend are now redirected onto the channel bed. Due to downstream grade control, this is only anticipated to cause localized scour at the toe of the wall and not result in major adjustments to the channel.

Construction can likely be accomplished through the use of a partial stream diversion unless it is determined that significant grading on the opposing bank is required to manage the 100-year WSEL. In that case a full diversion and stream crossing will be required. The project will incur additional forest impacts for any work on the opposing bank.

This approach is primarily a structural approach to stabilize the meander bend and protect the adjacent sewer line. The primary benefit other than improved stability of the sewer infrastructure is a reduction in sediment supply to the Little Patuxent River by preventing further bank erosion.

*Site A, Option 2*

The general concept for Option 2 is similar to Option 1 in that is focuses on armoring the entire length of the meander which has potential to erode with stone so that it can resist the erosive forces of the flow. Option 2 proposes the addition of the in-stream structures such as stone vanes that function to direct the thalweg to the center of the channel and initiate meander development. This effectively reduces shear stress and bank erosion in along the stream banks.

As a consequence, the degree of armoring and grading on the stream banks will be reduced; however, the proximity of the existing interceptor sewer to the bank poses a design constraint as the structures will need to be keyed into the stream bank. The reduction in frequency of structures along the bend will allow for natural vegetation and riparian functions to reestablish.

The additional roughness and angle of the in-stream structures from the bank to the bed will likely affect the 100-year WSEL such that additional grading of the opposing bank is required to maintain the flow capacity.

The impacts are similar to those of Option 1. To install the in-stream structures a full stream diversion may be required or construction will have to be phased so that construction is only occurring on half of the channel at a time. In this case, a full diversion and stream crossing will be required. The project will incur additional forest impacts for any work on the opposing bank.

This approach also uses structures to armor the outside of the meander to stabilize the meander bend and protect the adjacent sewer line; however this alternative has the ability to soften the bank and provide more ecological benefits through the reestablishment of riparian vegetation. This benefit will serve to replace wetland functions and values that were lost as a consequence of the parallel interceptor construction.

*Site B*

Based on the geomorphic assessment, the primary problems in this reach are; 1) migration of meander bends that result in exposing additional portions of the interceptor sewer, 2) continued channel widening that could potentially expose additional lengths of sewer infrastructure, and 3) channel incision caused by lack of geologic controls and localized adjustments in the stream profile associated with potential meander cutoffs. These problems have the potential to collectively expose and damage both the existing and proposed sewer infrastructure. The following options address these conditions.

*Site B, Option 1*

Option 1 or Site B proposes to armor the outside meanders while maintaining the existing stream alignment and install both in-stream structures to promote channel stability and grade controls at the sewer infrastructure to inhibit channel incision. The primary goal of this approach is protect the infrastructure from the erosive forces of channel flows. The stone vanes will be used to promote channel stability within the reach and transition the stabilized reach back to the existing channel. Approaching the sewer infrastructure, the banks will be armored to inhibit any additional bank erosion or channel migration. A grade control structure that is engineered to allow fish passage and maintaining a depth to prevent potential scour is proposed at the channel crossing. To achieve the appropriate slope and tie-in elevations this structure may extend into the meander downstream, where additional stone vanes are proposed to transition back to the existing channel. In some areas, minor channel filling will take place to create a bankfull bench that will be vegetated with riparian trees and shrubs.

The reduction in length of armoring structures in comparison to other options along the bend will allow for natural vegetation and riparian functions to be re-established. Proposed modifications

for this option are primarily bankfull benches and point bars. This option addresses all the active channel processes.

This option forces the stream into a naturally unstable alignment through the use of structures. Further, the additional roughness and angle of the in-stream structures from the bank to the bed will likely affect the 100-year WSEL such that additional bank grading is required to maintain the flow capacity.

The impact areas are limited to areas immediately adjacent to the existing stream channel. To install the in-stream structures a full stream diversion is required due to the existing channel being the primary construction route to supply materials and means for movement within the channel.

This approach uses structure to armor the outside of the meander to stabilize the meander bend and protect the adjacent sewer line; however this alternative has the ability to soften the bank and provide more ecological benefits of re-establishing riparian vegetation. This benefit will serve to replace wetland functions and values that were converted as a consequence of the parallel interceptor construction.

*Site B, Option 2*

The general concept for Option 2 is similar to Option 1 in that is focuses on stabilizing the channel through the area of concern, but it accelerates the natural meander adjustment by relocating the channel bed away from the crossing. Although this will increase the channel slope locally, a riffle feature will be created over the existing sewer line that can be armored with a grade control structure to protect infrastructure. Similar to Option 1, in-stream structures will be used to transition in and out of the restoration reach and bank stabilization is proposed along areas adjacent to the sewer infrastructure. Channel fill from the relocated sections could be placed in the abandoned channel to balance the earthwork and create bankfull benches that will increase the channel capacity to convey the 100-year storm. These benches would be vegetated with native species and depressional wetlands could be formed to provide additional ecological benefits. The major area of impact is the area already associated with the disturbance for the proposed parallel interceptor sewer.

This approach restores a more stable alignment that is consistent with the channel planform in other reaches that were evaluated. Further, crossing the existing sewer at an alternate location allows for more room to transition the proposed grade control to the existing bed before entering the downstream meander. In addition, the creation of bankfull benches has potential to be considered as mitigation for the parallel interceptor sewer construction, and also provide additional flood storage in the area. Relocating the channel bed location at the sewer crossing will create a more efficient channel section to improve the channels ability to convey flow without increasing the 100-year WSEL. Raising the channel invert in the location at the sewer crossing could potentially create backwater features to the upstream sewer crossing, thereby eliminating that fish passage blockage or reduce the severity of the blockage.

The additional roughness and encroachment of the in-stream structures on the channel will likely affect the 100-year WSEL. Further, crossing the sewer at a different location will likely result in setting the channel invert higher, which will result in an increase in the 100-year WSEL.

The overall impacts are anticipated to be less due to Site B already being disturbed from utility work. The project could be phased so that the majority of construction could be conducted without a stream diversion. Potential phasing would include construction of the realigned channel, diverting flow into the new channel and filling the abandoned channel.

This approach uses structures to stabilize the sewer line yet results in ecological benefits from the construction of bankfull benches. This approach will serve to replace wetland functions and values that were converted as a consequence of the parallel interceptor construction.

*Site B, Option 3*

For similar reasons to Option 2, Option 3 proposes major channel realignment by relocating the unstable meander bend at the sewer line crossing and creating a new meander bend over the sewer line north of manhole 1357. Similar to the other options, in-stream structures will be used to transition in and out of the restoration reach and bank stabilization is proposed along areas adjacent to the sewer infrastructure. Channel fill from the relocated sections could be place in the abandoned channel to balance the earthwork and create bankfull benches that will increase the channel capacity to convey the 100-year storm. These benches would be vegetated with native species and depressional wetlands could be formed to provide additional ecological benefits. A riffle grade control would be constructed downstream of the proposed sewer crossings to function as protection of the sewer line from scour and allow fish passage.

The benefits, disadvantages, constructability and mitigation potential are similar to Option 2; however the environmental impacts differ. This option will result in a significant disturbance to adjacent mature riparian forest and potentially encroach on private unimproved land. Additional encroachment of the 100-year WSEL may result from raising the stream invert to cross the sewer at a higher elevation.

Selected Options for Stream Mitigation

HODPW would like to pursue Options 1 or 2 at Site A and/or Options 1, 2, or 3 at site B to provide compensatory mitigation for unavoidable impacts to streams within the project corridor. These options would provide the most benefit for the surrounding environment while at the same time allowing for the protection of existing infrastructure in the vicinity. Stream blockages associated with existing infrastructure could be alleviated, opening up additional linear feet of stream channel during normal flow conditions. In addition, the correction of stream alignment issues and the rehabilitation of eroding banks in the area will serve to balance sediment loads and improve water quality throughout the reach.

***Memorandum of Agreement for Securing Mitigation Properties***

Howard County and Columbia Association met on November 7, 2007 to discuss an arrangement for the use of CA Open Space lands for the development of compensatory mitigation for the

impacts described above. Based on this meeting, a letter was drafted and signed by both parties indicating that CA has agreed in principle to allow the use of CA Open Space lands for the development of wetland and stream mitigation related to the Little Patuxent Parallel Sewer Interceptor project, pending a comprehensive analysis by CA of their current and future use of these lands. A copy of this letter is included as Appendix E to this report.

## Conclusion

We trust that the enclosed information is sufficient to issue a determination on the acceptability of the proposed mitigation plan for unavoidable impacts associated with the LPPSI. As such, we would appreciate as expeditious a review of the enclosed materials as may be possible so that the required Public Notice for MDE and USACE can proceed and a project authorization can be issued shortly thereafter.

Should you have any additional questions please do not hesitate to contact me at (410) 316-7865 or vie email at jderiu@kci.com.

Very truly yours,
**KCI TECHNOLOGIES, INC.**

James E. Deriu
Senior Environmental Scientist
Associate

Attachment 1: Site Location (ADC) Map
Attachment 2: Proposed Mitigation Locations: Wetland and Stream Mitigation Sites
Attachment 3: Soils, NWI, and FEMA-Designated Floodplain Mapping, Leaftreader Way Mitigation Site
Attachment 4: Historic Aerial Photographs, Leaftreader Way Mitigation Site
Attachment 5: Field Verified Site Conditions, Leaftreader Way Mitigation Site, November 2007
Attachment 6: Generalized Site Conditions Map, Stream Sites Visual Assessment
Attachment 7: Geomorphic Study Locations, Streams Sites A and B

Appendix A: Representative Site Photographs of Wetland and Stream Sites
Appendix B: Proposed Treatment Locations, Leaftreader Way Mitigation Site
Appendix C: Proposed Treatment Options, Stream Site A
Appendix D: Proposed Treatment Options, Stream Site B
Appendix E: Memorandum of Agreement: Columbia Association and HODPW
Appendix F: References

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